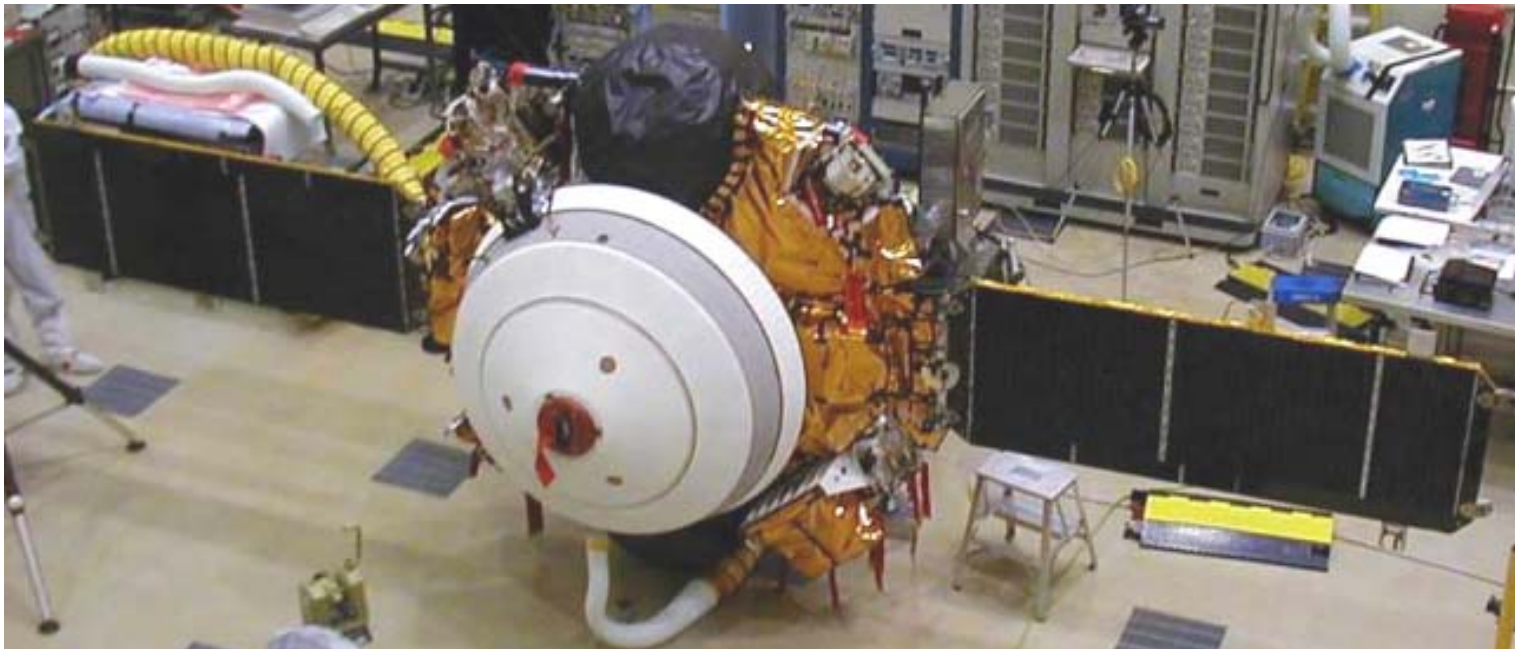# NASA - Risk Management Case Study
The Genesis Project

Richard B. Bennett

May 18, 2004

- **Mission Overview**

- **RM Approach**
  - **Objective**
  - **Implementation**

- **Evolution**
  - **CRR Board View**
  - **Cost, Schedule & Analysis**
  - **The Changing Mgmt Focus**
  - **Risks & Problems**

- **Analysis Products**
  - **Critical Path**
  - **Launch Date**
  - **PRA & Mission Risk**

- **Lessons Learned**

Mission Overview

- **Genesis is NASA's Discovery 5 Mission Selected in December 1997**
  - **Collect and Return Solar Wind Materials and**
  - **Use Them To Address the Processes Involved in the Origins of the Solar System**
  - **Launched August 8, 2001**
- **The Partners**
  - **Dr. Don Burnett / California Institute of Technology: Principal Investigator**
  - **Jet Propulsion Laboratory - California Institute of Technology : Project Management / Canister Payload / Mission Operations**
  - **Los Alamos National Laboratory: Monitor Payload**
  - **Johnson Space Center: Contamination Control / Payload Cleaning & Assembly / Sample Curation**
  - **Lockheed-Martin Astronautics: Spacecraft & Sample Return Capsule**
  - **McREL: Outreach**
  - **Boeing Launch Services. Inc. / Kennedy Space Center: Delta II Launch Vehicle & Integration Support**
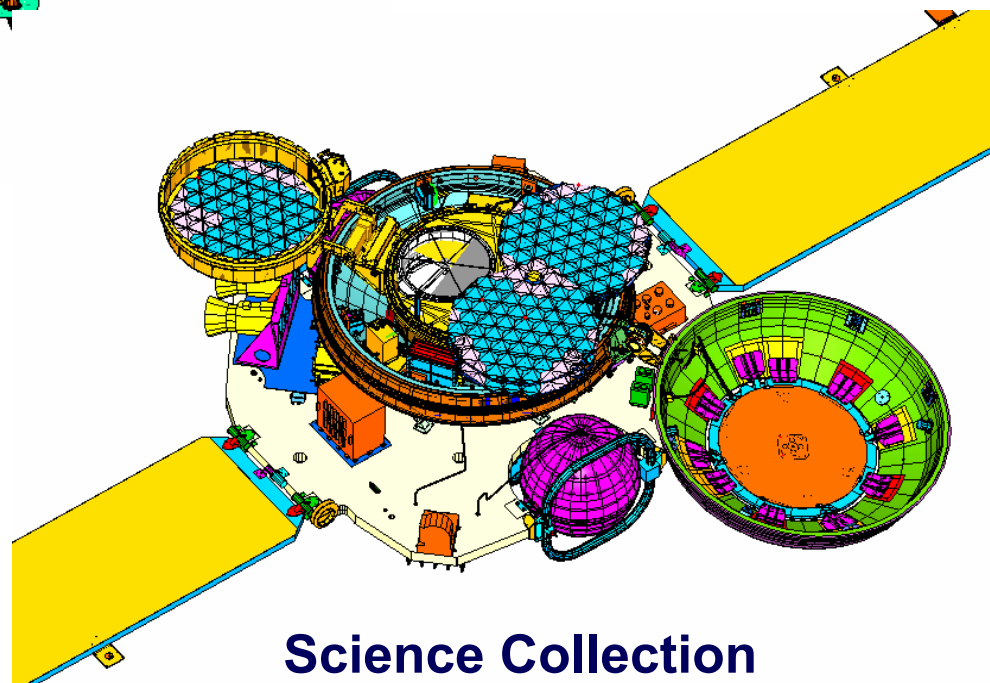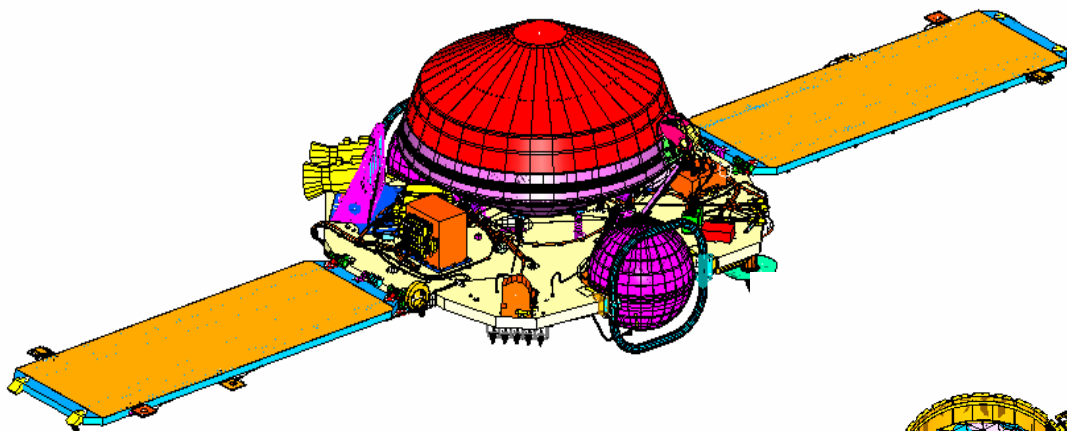
Cruise

Science Collection
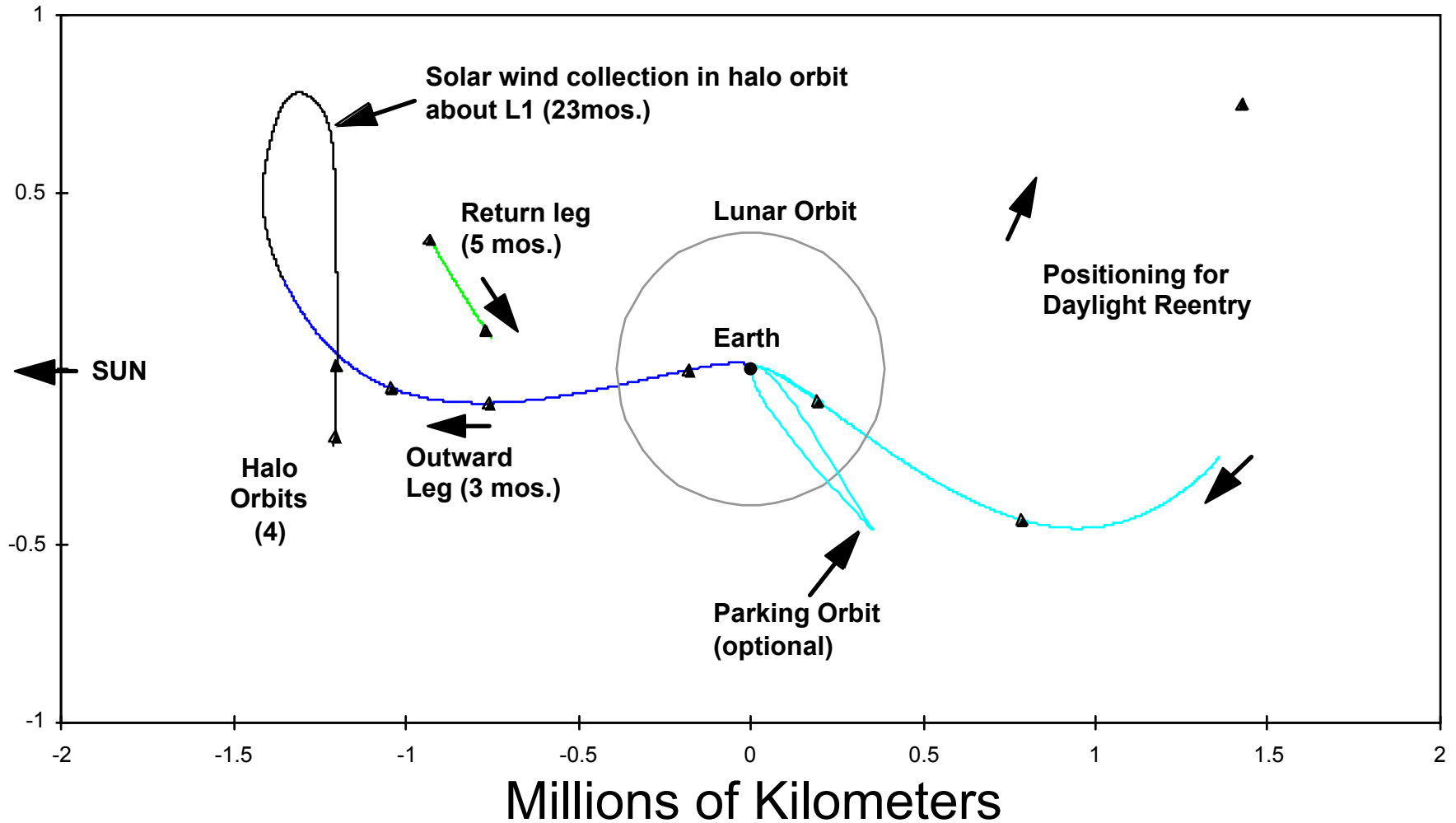
For More Information Visit:
www.genesismission.org

- **The Genesis Project Initiated a Formal Risk Management Program to Contain Cost, Schedule, and Technical Risks**

    - **It Needed to Be Comprehensive Enough to Include and Describe What to Do, When to Do It, and How to Do It for All Elements of Risk Management at All Stages of the Project**
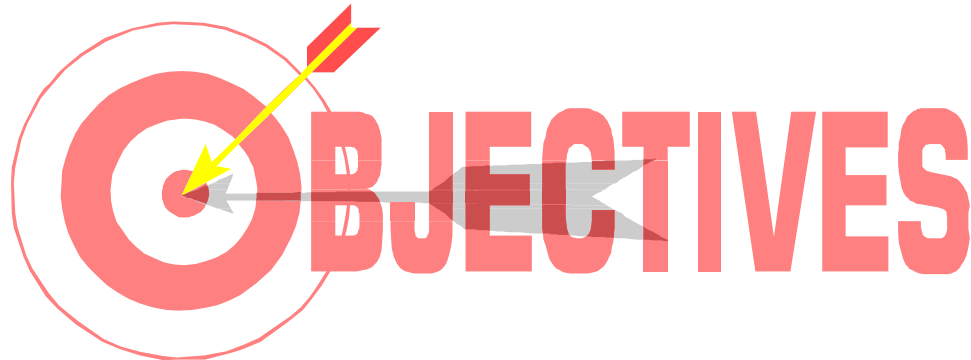
- **The MSE or the MAM ???**

- **Genesis Looked for Cost Effective Support. . .Futron[1]**
  - **Project RM Plan**
  - **Team Training**
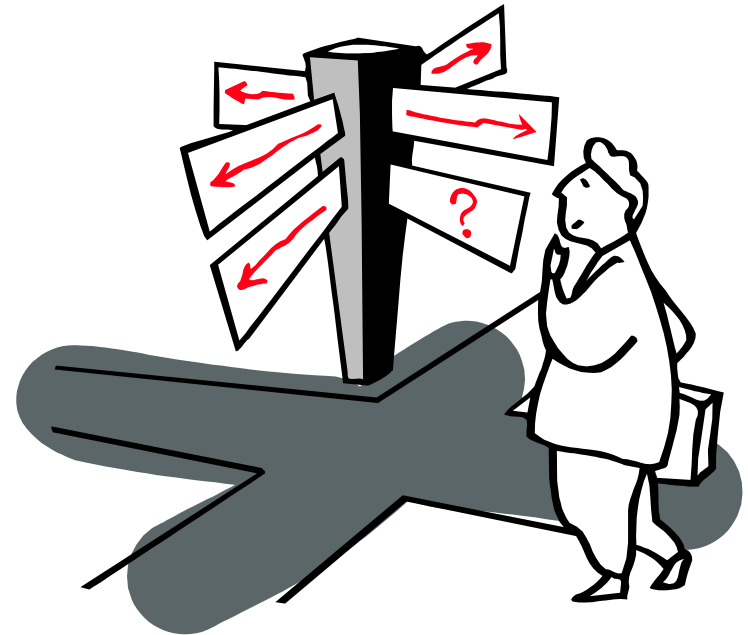 - **Independence**
  - **Analysis**

- **The Industrial Partner Dilemma**

1. Futron Corporation • 1120 NASA Road 1, Suite 310 • Houston, Texas 77058
Phone 281-333-0190 • Fax 281-333-0192 • www.futron.com

Responsibilities

Responsibility	Risk Manager	Element Managers	WBS LIII & IV Managers
Risk Management Plan	✓		
Risk Management Information System	✓		
Risk Management Process (Distributed)	✓	✓	✓
Risk Management Process Evolution	✓		
Level II Reporting and Tracking		✓	
Level III Risk Reporting and Tracking			✓
Risk Inputs		✓	✓
Risk Ownership		✓	✓
Day-to-day Execution			✓

- **CRR Board and the "Risk Zealot"**

- **Cost, Scheduling and Analysis**
  - **"Never - The - Twain - Shall - Meet"**
  - **A "Good" Schedule Network is an Art !!!**

- **The Ever-changing Management Focus**

- **Risks & Problems**
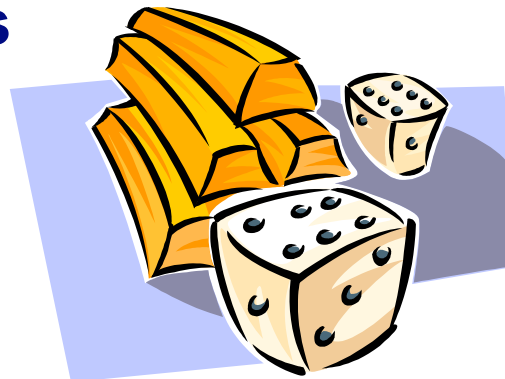
Critical Path Analysis
Risk & Problems vs. Criticality

Reference: GN_Master_Schedule 02/01/00

Flight Model Conc, Design, fab, assemble, test

Flt Canister Integration

These tasks can be placed on the watch list

Studies:Launch, Precession, Halo Orbit,Trajectories, Capture Orbit, Entry Analysis

Flight C&DH

Thermal Vac Test

ATLO Flow

SC-4 → Install & PT #1 → S/C-8A → S/C 10-11D → S/C 12, A,B- TV Tests → S/C-13B-14 → S/C-15-17A → S/C-18-20 → S/C 39 → Launch

Star Tracker

FSW-5

ACS Input

FSW-4

FSW-3

Critical Path and Criticality index

100%	
58%	Significant Problems
52%	
48%	High/Med Risk Task
42%	

Critical Path Analysis
Schedule Risk Impacts

TASK	Mean Days @Risk	Δ-Days to Criticality 1	Likelihood Exceed Crit #1	Δ-Days to Criticality 2	Recommended Action
Star Tracker Design, Purchase, Receive & Test	33	42	45%	75	Build contingency scan mode development, watch until exceed triggers, Execute when triggers = TRUE (See next chart)
GN FSW BUILD 3.0 Delivery to ATLO for ACS testing (MST 3)	12	55	0%	95	Accept, Place on watch list, reduce risk to "green" based on low likelihood
ACS Inputs for FSW Build 3.0	8	58	0%	94	Ditto, above
Flight Model Conc, Design, fab, assemble, test	7.8	56	0%	99	Ditto, above
LANL EM Conc Func Test	7.8	34	0%	75	Ditto, above
FSW Build 3.0 (StarTracker Risk Mitigation)	5.9	N/A	N/A	N/A	Part of the contingency plan for the Star Tracker
ACS Inputs for FSW Build 5.0	0	0	62%	39	Not a risk item, but need to reduce sensitivity by decoupling from critical path
Genesis SW Phase 5 delivery	0	0	62%	39	
Launch	2.6	0	100%	46	All of the above

Note:

Criticality 1 is day-for-day slip from 10/30/00

Criticality 2 is day-for-day slip beyond nominal launch

Crit 1
10/30/00
Launch
Ready

Crit 2
1/5/01
Nominal
Launch

Plan

Nominal launch, day-to-day slip begins

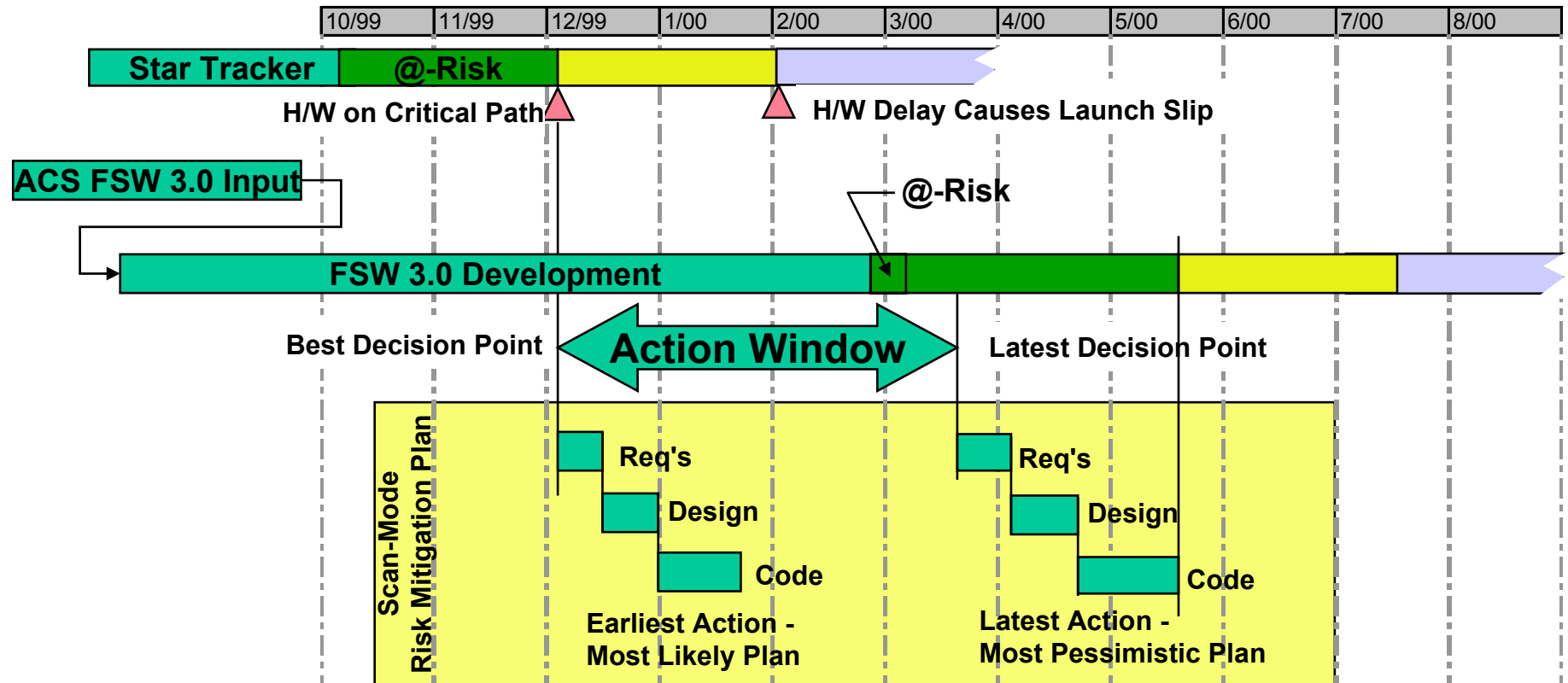**Activity late, but not on critical path**

Activity late, AND on critical path, day-to-day slip begins
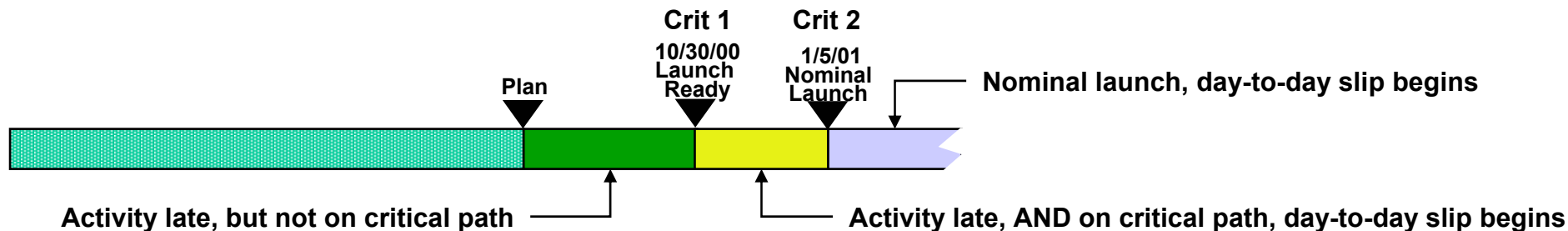
Critical Path Analysis
Managing The Star Tracker

- **Star Tracker OK until 42 days late, 12/8/99, and 45% chance WILL be this late**
- **Star Tracker Hardware must be accepted by 2/1/00 or day-to-day launch slip is 80% likely**
- **On 12/8/99 window opens for decision to initiate Scanner Mode Design Change, decision to implement after 3/18/00 puts FSW 3.0 on the critical path**
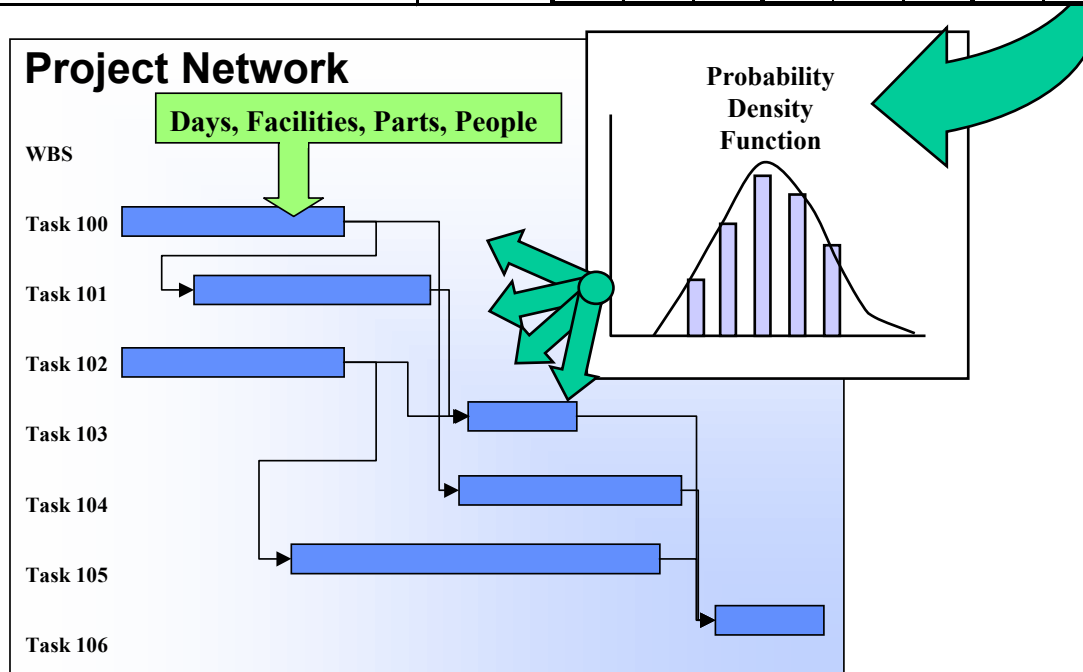
Launch Date Analysis
Risk Inputs

		Probable Impacts in Days Duration																			
		Star Tracker Design, Purchase, Receive & Test			FSW BUILD 3.0 Delivery to ATLO for ACS testing (MST 3)			ACS Inputs for FSW Build 3.0			FSW Build 3.0 (StarTracker Risk Mitigation)			LANL EM Conc Func Test			Flight Model Conc, Design, fab, assemble, test		
Activity	Likelihood	Min	M/L	Max	Min	M/L	Max	Min	M/L	Max	Min	M/L	Max	Min	M/L	Max	Min	M/L	Max
Concentrator is a new development, may not be delivered in time	67%													8	11	14	8	12	15
EMS Star Tracker is a new development and may not be delivered on time	80%	21	42	62	10	15	20	5	10	15	5	7	10						

Project Network

Days, Facilities, Parts, People

Probability Density Function

WBS

Task 100
Task 101
Task 102
Task 103
Task 104
Task 105
Task 106

Launch Date Analysis
Risk - Based Margin

Note: The baseline plan contains 781 days of funded margin. Setting all margins to zero results in a launch date of 10/18, yielding actual margin to launch of 57 days, i.e. the "green" shaded area in the graph. The "yellow" shaded area encompasses the two launch windows. The "red" area indicates a missed opportunity.
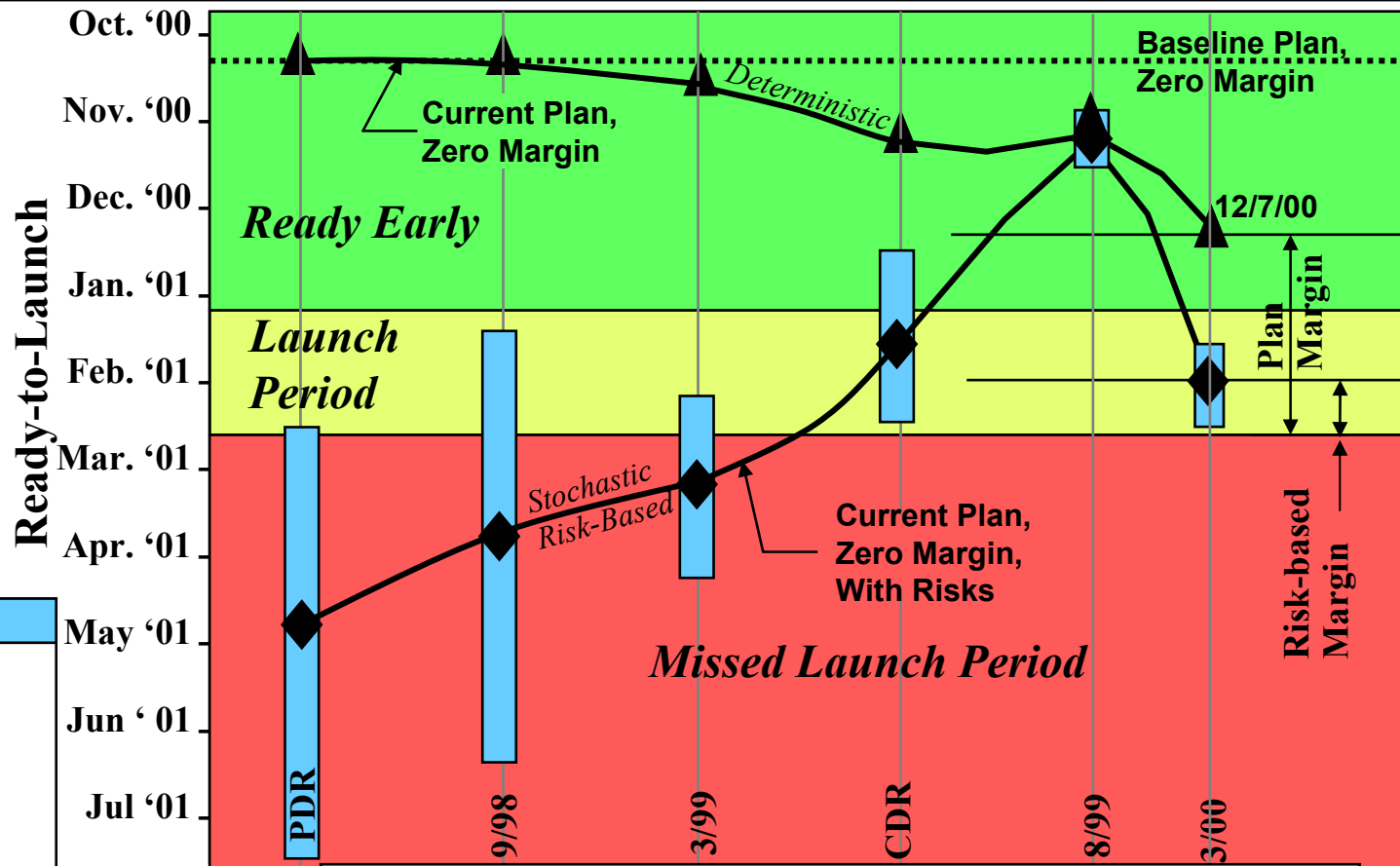
LEGEND

Risk-based Launch Ready & Confidence

- −20%-tile
- −Mean
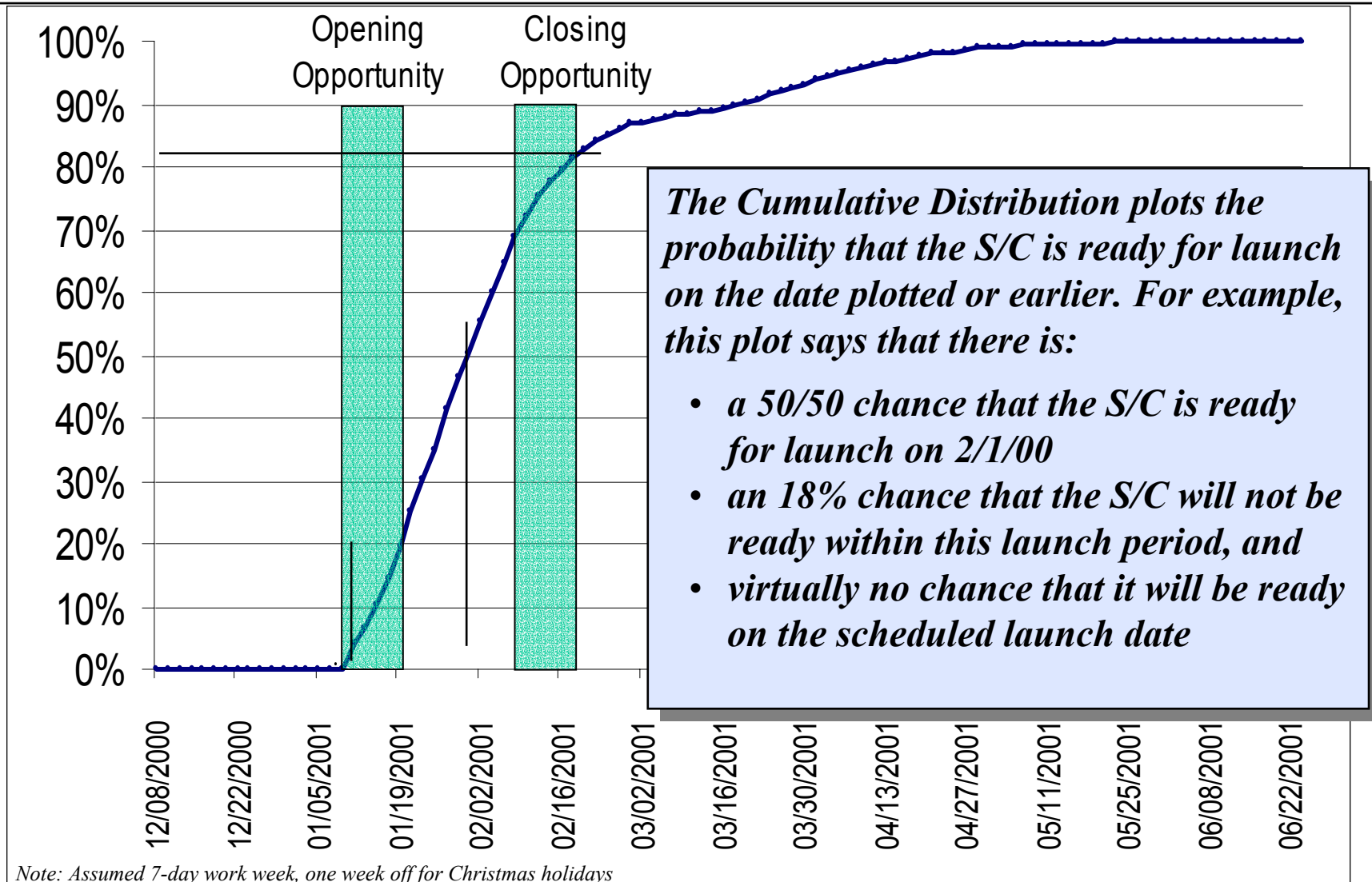- −80%-tile

Current Plan, Zero Margin

Current Plan, Zero Margin, With Risks

Late HW deliveries (including Star Tracker) have driven the deterministic schedule date downward. SW risks (1st) and Star Tracker (2nd) are major risk drivers on the stochastic schedule estimate.
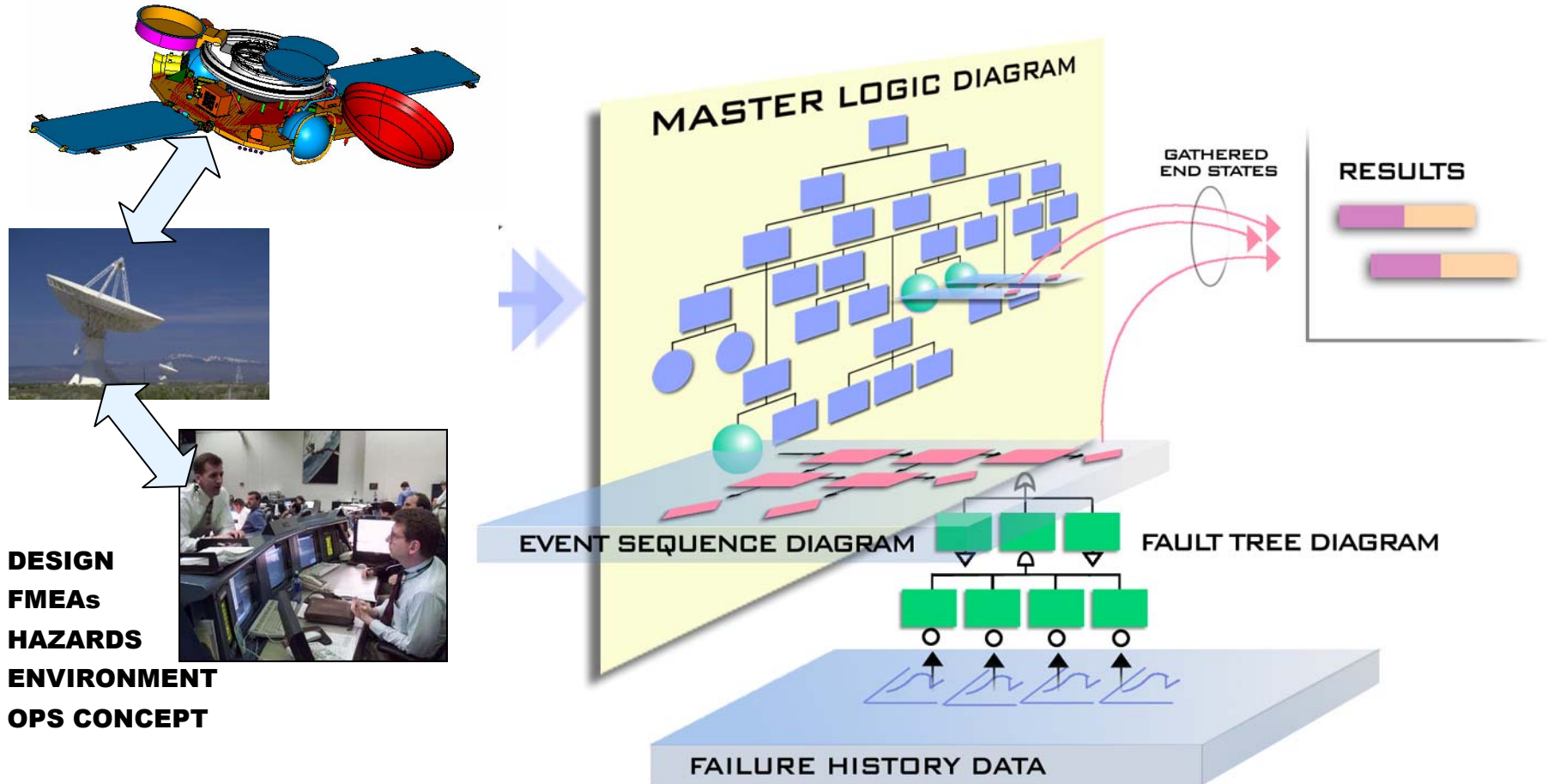
Launch Date Analysis
Cumulative Distribution

The Cumulative Distribution plots the probability that the S/C is ready for launch on the date plotted or earlier. For example, this plot says that there is:

- a 50/50 chance that the S/C is ready for launch on 2/1/00
- an 18% chance that the S/C will not be ready within this launch period, and
- virtually no chance that it will be ready on the scheduled launch date

Note: Assumed 7-day work week, one week off for Christmas holidays

DESIGN
FMEAs
HAZARDS
ENVIRONMENT
OPS CONCEPT

MASTER LOGIC DIAGRAM

GATHERED END STATES

RESULTS

EVENT SEQUENCE DIAGRAM

FAULT TREE DIAGRAM

FAILURE HISTORY DATA

A holistic analysis of primary systems, support systems and people.

GENESIS
SEARCH FOR ORIGINS

- **Two Plots**

  - **Probability and Confidence**

    - **Uncertainty Due to Imperfect Knowledge of Actual Failure Rates**

    - **Different Sources**

    - **Assumes Perfect Modeling**
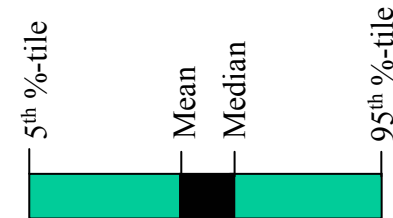
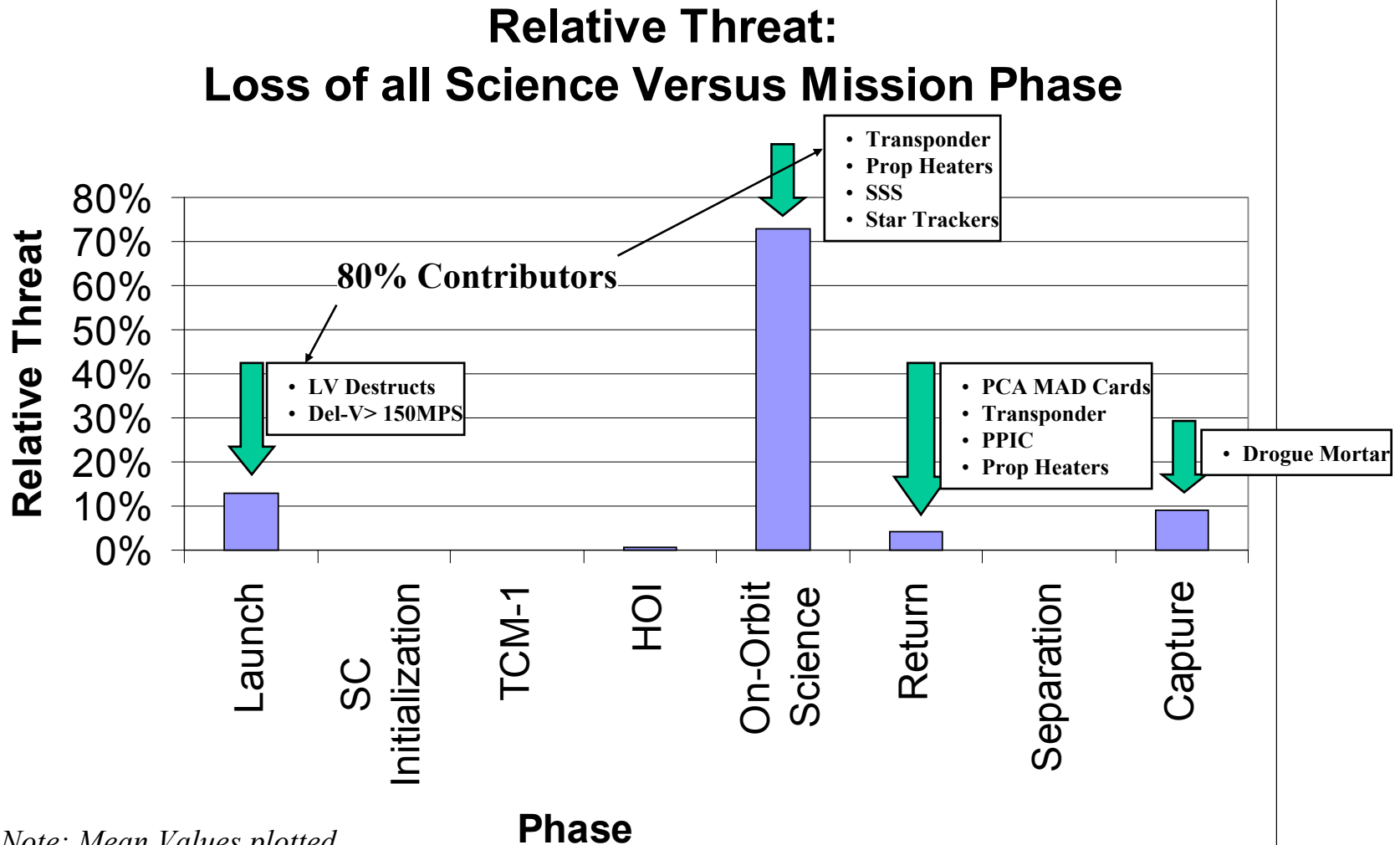 - **Importance Ratio**

    - **Extract Subsystem or Components Contributing to ≥ 80% Failure**

    - **Normalize to Determine Relative Contributions**

    - **Allows Focusing on Drivers**

    - **Only Selected Charts Shown; All Available but Not in Presentation**
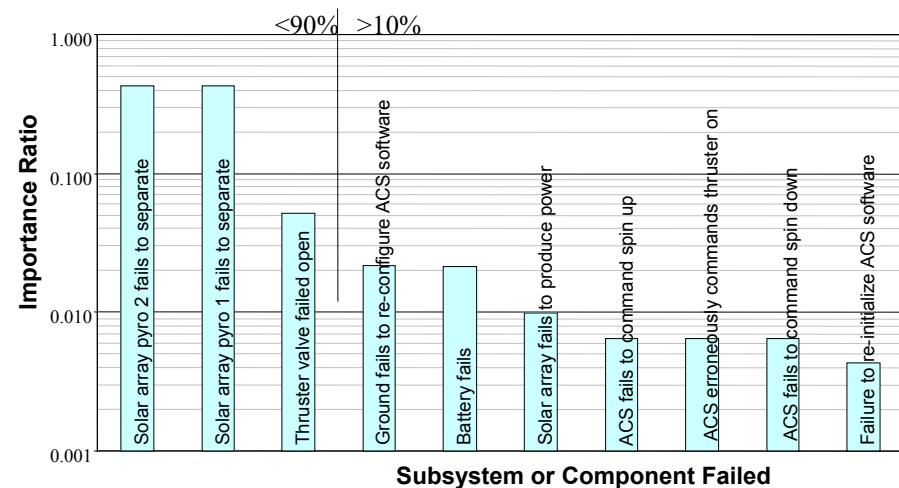
Relative Threat:
Loss of all Science Versus Mission Phase

- **To Limit *Risk Management Training* Because of the Training Cost, Is a False Economy.**

- **A Strong Position Must to Be Taken by *Project Management to Enforce Participation* in the Process.**

- ***Keep the Risk Input Form SIMPLE!* If More Data Is Needed, Collect It in an Interview Session.**

- ***Validation of the Tools and Input Data* Needs to Be Done Early in the Project.**

- ***Being Proactive* Is Extremely Valuable.**
  - **An Unheeded Risk Is a Waste of Resources**

- ***Expect the Risk Management Process to Evolve*** **With the Project and Its Ever-maturing Needs.**

- ***Tailor the Process*** **and the Information That It Produces to Match the Project and Its Management Culture and Desires; Do It Early and Continuously.**

- ***Indirect Benefits of Quantitative Risk Analysis*** **Due to the Demand for Quality Project Management Data Are As Valuable As the Direct Benefits.**